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## **SUMMARY and RESULTS**

**“Salmon, Climate Change and WDFW”**  
***A pilot workshop to explore vulnerability and  
resilience to a changing climate***  
***February 27-28, 2013***

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## 1.0 Overview

This report provides a summary of a 2013 WDFW workshop focused on reducing the risk climate change poses to agency activities and our success in achieving our objectives. The workshop was developed as a pilot project and we chose the Skagit Basin as a focal area. At the broadest scale, our charge was to consider specific activities related to fish and aquatic habitat management in the Skagit Watershed, and explore how those activities might be affected by climate change.

The workshop goals were threefold: (1) to advance understanding of how climate change will affect our ability to achieve our goals for fish management and salmon recovery – in the Skagit basin and statewide, (2), explore options to integrate climate change into decision-making processes and (3), identify an adaptation road map and next steps for moving forward.

The following narrative describes the background and context for the workshop, explains the methodology and provides both summary and detail of workshop results. The final section proposes some next steps for consideration by WDFW.

## 2.0 Background and Context

### ***HOW CLIMATE CHANGE WILL AFFECT OUR CONSERVATION GOALS***

Climate change poses many consequences for Washington's fish and wildlife, with especially profound impacts for salmon restoration and aquatic habitat conservation goals.

#### **Coastal Habitat**

Many of the state's coastal wetlands, tidal flats, and beaches are likely to change substantially in quality and extent due to an accelerating rate of sea-level rise, particularly where upland migration of habitats is hindered by bluffs or anthropogenic structures such as dikes, or where natural sources of sediments are limited (Glick et al. 2007). Loss of key coastal habitats could have a significant impact on associated species such as shorebirds and forage fish, as well as place coastal infrastructure and communities at greater risk from coastal storms (Krueger et al. 2010; Redstone Strategy Group LLC 2008).

#### **Changing Ocean Chemistry**

A combination of factors renders the Pacific Coast especially vulnerable to ocean acidification, as naturally more acidic deep ocean waters brought to the surface through upwelling combine with waters whose pH has been reduced by anthropogenic carbon dioxide (CO<sub>2</sub>; Feely et al. 2008). Higher acidity inhibits calcium uptake and erodes the basic building blocks for shells and skeletons of marine invertebrates, which are a foundation of the marine food web (Barton et al. 2012; Orr et al. 2005). Evidence suggests that acidifying ocean conditions may already be affecting some species (Feely et al. 2012; Hauri et al. 2009; Wootton et al. 2008).

## **Freshwater Habitat**

Climate change is already having a significant impact on the state's freshwater aquatic systems, including higher average water temperatures and altered hydrology, and projections for the future suggest more dramatic changes to come (Elsner et al. 2010). Among the numerous species of fish and wildlife that depend on these systems, the region's salmonids stand out as especially vulnerable given that they are expected to face climate change impacts throughout their complex life cycle (Martin and Glick 2008; Mantua et al. 2010; Wade et al. 2013).

### ***DEVELOPING A CLIMATE ADAPTATION PROGRAM WITHIN WDFW***

The agency has been working to understand how climate change will affect agency activities for some time, and in 2008 formalized its efforts with the adoption of a set of strategic climate change goals. These goals led to an adaptation program focused on four major areas: education and outreach, science, collaboration with partners, and integration into agency activities. A few highlights of activities to date include [published summaries](#) of key impacts on major habitat types across the state, a series of educational workshops for staff, and partnering on several climate related research projects, including habitat connectivity, and a [climate change vulnerability assessment](#) for species and habitat across the Pacific Northwest. However, the fourth area, integration, or "mainstreaming" climate considerations into daily work has proven to be more challenging. How do we translate what we know about future change from the science and apply it to relevant activities in a meaningful way? What could we, or should we, do differently because of future climate change?

### ***IDENTIFYING CLIMATE SENSITIVE DECISIONS AND ACTIVITIES***

To answer this question, we have begun evaluating major activities and agency investments, including land acquisition, restoration projects, technical assistance and grant-making, species management and recovery efforts, permitting, and infrastructure design and management. Within each of these activity areas, our intention is to identify specific activities that may be affected by climatic changes, and then to develop options that will increase the opportunities of success over the long term. The Skagit Workshop represents a pilot project, testing one way to engage appropriate staff in tackling these questions for a limited set of activities. Also, in choosing to examine just one watershed, albeit the largest of Puget Sound, we were testing whether a limited geographic focus was helpful to the process. The next section describes in more detail the approach and methodology of the workshop.

## **3.0 Approach and Methodology for the Skagit Workshop**

The overarching purpose of the workshop was to identify and explore options for ensuring that WDFW activities and investments would be resilient and successful over time in light of climate change. A core team consisting of the climate change coordinator, a habitat biologist from the Skagit region and a research scientist from the Fish Program met regularly to plan the workshop content and develop advance materials. We also established a larger advisory team consisting mostly of agency staff working in the Skagit region. The advisory team met several times early in the planning process, to help ensure that the content would be relevant to agency work.

The workshop was designed to bring agency staff working in fisheries management and aquatic habitat restoration together with climate adaptation experts and climate researchers. The aim was to provide enough background and climate change data to adequately inform the conversation about which agency policies, activities and decisions are sensitive to impacts expected from climate change and the degree to which this sensitivity might put the success of our goals at risk.

Another aspect of the workshop was to test whether focusing on one watershed made identifying sensitive activities and decisions easier, and how much of the findings could translate statewide. We chose the Skagit Basin for our pilot in part because the [Skagit Climate Science Consortium \(SC2\)](#), a group of scientists working to assess, plan, and adapt to climate related impacts, is actively working in the basin. We formed a partnership with SC2, and worked with the SC2 Coordinator and several of their scientists to inform our workshop agenda, to recommend reference material, and to provide presentations at the workshop itself.

## **WORKSHOP COMPONENTS**

### ***Presentations of Research***

The two-day workshop began with a series of presentations from climate scientists, biologists, and geologists that provided scientific and management context for topics participants would be discussing. Brief presentation summaries are provided below for the eight speakers.

**Dr. Jennie Hoffman**, formerly with Ecoadapt ([ecoadapt.org](http://ecoadapt.org)), “Making Climate Adaptation Real – examples from the field”. Jennie provided a geographically wide overview and discussion of approaches and actions natural resource managers have taken to incorporate climate change into long-term planning. By evaluating how current and planned activities would be affected by climate change, we minimize waste of time and money and maximize success. She recommended several habitat restoration or management plans as useful models for integration of expected climate change impacts. For example, designating critical habitat for shoreline nesters or spawners required projecting sea-level rise effects. She encouraged us to view climate change as one more element of future uncertainty that can easily be incorporated with other uncertainties in long-term planning.

**Bob Everitt**, WDFW Regional Director for Region 4, “Overview of WDFW's work in Skagit Basin”. Bob shared his knowledge and insight of WDFW's Skagit Basin and Region 4 activities. Skagit Basin is by far the largest Puget Sound watershed and hosts the full range of WDFW resource management activities. Among many management partners are three tribes: Swinomish Indian Tribal Community, the Sauk-Suiattle Indian Tribe and the Upper Skagit Tribe, with whom WDFW shares decisions on fish, wildlife and habitat. WDFW-owned lands include 10 Wildlife areas, many of which are in lowland and estuarine areas that are vulnerable to sea-level rise. Agriculture is a dominant area land use, and forms a major community that WDFW partners with for local resource and recreation management.

**Ingrid Tohver**, University of Washington-Climate Impacts Group ([cses.washington.edu/cig/](http://cses.washington.edu/cig/)), “Climate Change in the Skagit Basin”. Ingrid presented an overview of global and regional

trends in, and projections of, water and land temperatures and precipitation. In the Pacific Northwest, wetter winters, springs and falls, but drier summers are expected by mid-century. Loss of snow cover is a significant impact expected from warming temperatures. Skagit River hydrograph is expected to change to higher winter (Dec. to Mar.) flows and a loss of May to June peak flows, due to more winter rain than snow, less snow pack and earlier snowmelt. Flood severity is also expected to increase. Summer low flows and higher temperatures pose significant risks to fish populations. Sea-level rise, which regionally could be in the range of 20 inches by 2050, is projected to cause transitions in nearshore habitat types, such as brackish marshes converting to tidal flats.

**Dr. Jon Reidel**, National Park Service, “Projected and Observed Changes in Skagit River flow due to Climate Change”. Jon shared details of modeling results on impacts of warmer winters on Skagit flooding. Hydrographs also will be affected by Cascade mountain glacial ice losses. Jon demonstrated how losses already have been significant with photo comparisons between early- to mid-1900s to present. Since 1993, the Skagit’s glacier reservoir has a net loss of about 400 billion gallons, an equivalent of 44 years water supply at current Skagit County use rate. This loss particularly affects summer hydrographs. Geological aspects of Skagit’s river basin may ameliorate low flows. Several zones from Marblemount to Sedro-Woolley have surficial geologies that promote transmission and storage of groundwater. If winter rain does increase, its absorption as groundwater and percolation to river may mitigate low flows.

**Dr. Ed Connor**, Seattle City Light, “Climate change and Skagit River Salmonids”. Climate change impacts on riverine conditions, especially higher seasonal peak flows, reduced summer flows, increased sediment loads, and warmer water, are expected to directly affect survival of most of Skagit’s salmonids. Spawning, incubation, and freshwater rearing are the vulnerable life-history stages. For example, if peak flows are higher and shift from spring to early winter, egg and juvenile survival may be lowered. Lower summer flows combined with higher stream temperatures will especially affect salmonids with long freshwater rearing periods, such as steelhead, coho, and bull trout. Off-channel and tributary habitats provide refuge from poor mainstem conditions and thus are important to protect and restore. Identification and protection of cold water sources and habitats also will provide essential refuge areas.

**Dr. Eric Grossman**, United States Geological Service, “Sediment Transport and Restoration Objectives – Cumulative Climate Change and Sea-Level Rise Impacts”. The Skagit is a sediment-rich basin due to its young geology, high and steep elevations, and wet climate. Sediment movement and deposition affect habitat characteristics, and likely will be modified by climate change. Sediment loads increase as river discharge increases and highest loads have been observed in winter. Increased precipitation as rain and increased exposures due to less snow and glacial ice are expected to increase sediment loads and turbidity, and alter channel characteristics and nearshore deposition. Sediment delivery to nearshore areas affects stability and recovery of eelgrass habitats and associated biota, such as herring. The interaction of predicted sea-level rise and increased sediment delivery will determine outcomes for estuarine and shoreline habitats. Also, existing modifications to Skagit



floodplains and delta (e.g., channelization, dikes) will affect landscape responses. A variety of Skagit estuary restoration targets have been established and Eric recommended strategic phasing of projects to maximize success among objectives.

**Dr. Tim Beechie**, NOAA-Northwest Fisheries Science Center, “Incorporating climate change into salmon restoration planning”. Tim focused on two questions, 1) can we ameliorate future climate change effects with restoration?, and 2) how do we incorporate projected climate effects into river restoration designs? Restoration of riparian areas, natural flow regimes, and incised channels are three actions that appear to mitigate expected climate change effects by reducing stream temperatures, decreasing peak flows, and increasing flows during low flow season. Salmon resilience to climate change can be improved by restoration projects that increase habitat and ecological diversity. For example, removing longitudinal and lateral barriers in channels and floodplains increases habitat diversity, which promotes salmon resilience by expanding opportunities for life history diversity. Tim outlined how a restoration design process would use expected climate change effects in decision-making. This systematic inclusion of potential effects may show, for example, that objectives or design criteria should be modified. Expected changes in peak flows, which have already been increasing in many areas, particularly demand that a project’s physical design be based on updated flow accommodation criteria.

**Dr. Correigh Greene**, NOAA-Northwest Fisheries Science Center, “Opportunities to increase resilience for salmonids”. Correigh provided details on how each salmonid species will be differently affected by climate change due to their life history differences. He also outlined how for each species, all life history stages will be affected by climate change. Sensitivity or vulnerability to climate effects depends on, among other factors, time spent during a life stage in a particular habitat. For example, pink salmon and chum salmon juveniles spend very little time in freshwater compared to steelhead or coho juveniles and thus are less vulnerable to expected freshwater changes such as temperature increases. Species differences in spawn timing and habitat thus yield different vulnerabilities to expected changes in flow regimes and temperature. A species-specific matrix of climate change threat levels per life stage in fresh and salt water habitats was provided. Within species, it is apparent that life history variation can reduce population-level fluctuations and mitigate against survival variation caused by climate change. Habitat restoration in floodplains and riparian zones may best assist salmon adaptation to climate change.

### ***Identifying Climate Sensitive Decisions***

Participants then split into small groups organized by broad activity areas: harvest management, hatcheries, restoration, acquisition, hydraulic permits, and fish passage. Each of these groups used large charts taped to the wall to record and facilitate their discussion. Their first task was to identify key decisions the agency makes in the basin, and then for each decision, to determine how it might be sensitive to climatic change impacts, or whether or not climatic factors could affect the desired outcome of the activity. The second task was to identify risks of NOT addressing climate, or in other words to assess the likelihood that climatic changes will affect our success in that area. For example, what would be the risk of ignoring sensitivity to current or future climatic conditions and maintaining status quo? Finally, groups were asked to identify other information which might be needed or helpful to inform the

discussion. Please see Appendix 3 for a full display of completed wall charts. A narrative summary of each group's results follows in Section 4.0. Below is an example of chart headings provided to participants for the first task of identifying relevant agency decisions:

Topic area: <i>(for example, hatchery management)</i>			
Climate Sensitive Decisions	Why is this decision vulnerable?	How likely is it that climate will affect success?	What other information is needed?

### ***Identifying Adaptation Opportunities and Science Needs***

For those decisions, or activities, that ranked highly sensitive, the groups were then tasked to identify adaptation options, and policy issues and science needs relative to implementing a proposed option. For example, the harvest management group decided that the methodology used to develop yield models was highly sensitive to climate change because it is based on historical data and assumes static conditions that could possibly lead to over-estimated future production. In response, the group suggested that we need to test new models with new base periods and use more recent, shorter-term data sets. In order to advance this approach, the agency would need to work closely with tribal co-managers, recreational and commercial harvesters, and conduct additional research on parameters in existing model data sets that may be most sensitive to climate change impacts. An example of chart headings for the second task is provided below. Please see Appendix 3 for a display of all these completed wall charts.

Topic area: <i>(for example, hatchery management)</i>				
Climate Sensitive Decisions	Adaptation Options	Policy Implications (obstacles?)	Science or Information Needs	Stakeholders who need to be engaged

### ***Evaluation and Next Steps***

At the close of the small-group work, the full group reconvened and discussed questions about the design and value of the workshop, and specifically how to follow up on the work produced by the small groups. Highlights from this discussion are presented in Section 5.0.

## **4.0 Results by Activity Area**

Content from the wall charts (Appendix 3) produced by the small groups is summarized in narrative below. Please bear in mind that these findings should be considered preliminary, and serve as a place to start wider conversations. The ideas and observations represent workshop participants, and each topic area will benefit from additional perspectives and discussion.

### **HATCHERY MANAGEMENT**

#### **What decisions are sensitive to climate and why?**

**Flow management** issues were tagged as sensitive to climate change because of increases in spring flows and future projections for low fall flows (staff noted that we are already seeing some flow limitations in fall at Marblemount Hatchery). Not enough river flow may

increase hatchery costs since we would need to rely on more well water. Also changes in water temperature might affect growth rates.

**Release dates** of hatchery reared fish were also seen as sensitive because they are timed to maximize survival and physical condition. The goal is to match the timing of natural out-migration and to minimize potential impact to wild fish (related to release date). We want to match fish size and optimal environmental conditions for survival (food resources, water temperature, flow), and each of these may be affected by climate change. If timing in the establishment of food resources in receiving waters is changing, then we may need to change release time of hatchery fish. Decisions for release dates are a year out so it requires a lot of planning and advance information.

**Brood stock collection is also potentially vulnerable** – Climate affects ocean survival and may affect return timing for fish, which can have cascading effects on broodstock abundance and collection. The group viewed a changing climate as very likely to change the biological baseline for hatchery programs over time, which the group saw as having a potentially large effect on hatchery program operation and maintenance. This sensitivity was seen as especially likely to impact our success for species of low abundance, if ocean survival falls. Flow changes might also affect our ability to get fish for broodstock.

**Disease Issues** (in hatcheries and post release) are sensitive to climate because warmer temperatures or other variables affected by climate may affect the frequency of diseases. We may need to shift to a different water source.

### **Adaptation Options**

Only a few specific options were considered at the workshop, due to time constraints – more could be added.

1. Evaluate how we manipulate flows to the hatchery relative to future changes. We could do a cost/benefit analysis based on changing surface flow into the hatchery, changing flows from wells using pumps, recirculation strategies and opportunities to find different water sources or establish a new well.
2. Vary release dates relative to stream flows. If we don't have the capacity or flow to release fish later in the season, we may need to release fish smaller. Match the natural migration and consider multiple timing releases for single broodstock.
3. Develop a manual that guides hatchery facility managers to how change or reaching particular thresholds might trigger different action.
4. Conduct a hatchery vulnerability assessment - what characteristics will make some hatcheries more vulnerable to climate change than others? We could target our adaption response to those facilities.
5. Hatcheries – with new dollars from Jobs Bill [facilities updates] can we integrate climate change, and integrate into HGMPs? (Hatchery Genetic Management Plans)
6. Provide an example of a hatchery built & operated for climate change resilience

## Considerations

- For release dates; releasing smaller fish may have implications for harvest management in terms of higher mortality and fewer fish, which in turn might also affect broodstock collection.
- Smolt to adult recruit (SAR) projections or outcomes – tie into harvest management
- If the costs of altering flow goes up or availability of water for the hatchery changes, then we need to tee up a discussion.
- Water rights might be an issue if flow availability changes.
- Engage the Hatchery Scientific Review Group
- Fishery management and co-management need to be considered.

## Science Needs

- For release dates – need to understand the freshwater ecological consequences of altering the juvenile fish size at time of release. Need more monitoring to understand how release dates are working.
- For flow management, need information and monitoring data on flows and water temperature.
- Need a better understanding on diseases associated with different water sources.
- Need models to help us understand ground water flow (specific to wells if we expect changes to groundwater.)
- Need to better understand flood window (seasonality; for example, do not put fish in pond until Dec 15). Flood can affect the whole facility. Location of facility can affect maintenance.

## Suggested Next Steps:

### *Near-term*

- Have subsequent workshops to educate staff in other regions
- Complete manual of hatchery operations. As a precursor to this, could develop a manual template
- Formalize collecting data on baseline parameters in the hatchery to monitor change over time related to climate change

### *Longer-term*

- Adjust hatchery practices and operations accordingly following development of manual, etc.

## **ACQUISITION AND LAND MANAGEMENT**

The land acquisition group considered 1) all actions the agency takes in the process of acquiring land for new habitat or recreation values, 2) management objectives for lands the agency owns, and 3) prioritization and design of restoration projects on those lands.

## **What decisions are sensitive to climate and why?**

***The goals, criteria and priority setting process*** for selecting new property were seen as sensitive, as well as assessing operations and maintenance costs over time. These

decisions are sensitive because site conditions and characteristics may be altered over time as a result of changing climatic conditions, possibly to the extent that it will cause implications for the target species, communities or habitats, or may compromise the intended use or goal or may change operations and maintenance costs. For example, if the acquisition is intended to enhance habitat connectivity, we might need to consider how that value might change over time and/or how the connectivity needs of target species might change over time.

***Accurately assessing Operations and Maintenance costs*** were seen as another decision affect by climate -- the group posed the example of future changes in flows causing increased costs for maintaining boat launches and engineered solutions for fish ladders and culverts.

### **Adaptation Options**

1. Develop a strategy to purchase a suite of complex habitats so if one fails, others will flourish. Don't buy for single species.
2. Evaluate likely future climate-related conditions at selected site to evaluate if site will support targeted species/habitat/ecosystem service.
3. Acquire land for species at risk now and plan for needs to benefit them later. For example, select areas above sea-level now that may be good eelgrass beds in the future.
4. Look at climate projections to see if acquisition will be able to support public access/use as intended

### **Considerations**

- Need to be careful not to over-inflate climate risk, and that we can justify decisions.
- Shift in priorities for funding opportunities, i.e., buy for future value, not current.
- Funders expect land to provide single function forever; climate will change this.
- If you don't buy because of potential climate change impacts, you may risk negative reactions from interest groups that bring property forward.
- How will we make decisions and weigh future value versus current needs? Do we need a new framework?

### **Science Needs**

- We need to be able to determine how future conditions will affect biodiversity on site. Evaluate current conditions vs. what it will look like in future and see if purchase is worthwhile. Among the variables to evaluate:
- How will species ranges and habitats shift over time in response to changing climate?
- Risk of coastal inundation from sea level rise or other impacts such as increased storm surge, wave height, erosion.
- Fire regime change.
- Land use change around the property as humans respond to climate change.
- Ecosystem integrity change with climate change and how will we measure that?
- Riparian zone health/flow levels change.
- Water quality changes (temperature/sediment) could all affect success of connectivity variable in estuary, streams, riparian area. Some will be more resilient to change than others.

- What new species may move in and what management is needed – what do they need?
- Is the structure of your monitoring plan adequate in light of change projected from climate change?
- Integrate climate change into Lands 20/20 process

### **Suggested Next Steps:**

#### *Near-term*

- Develop guidance for staff preparing Lands 20/20 applications to help in answering the climate change question in the application.
- Evaluate responses to better understand what specific information will best inform decision-making and revise for next iteration.

#### *Longer-term*

- Develop a set of climate change-informed habitat priorities for protection/conservation (to be secured through a variety of tools, including acquisition). Given what we understand about climate impacts, what are the top either habitat types, or characteristics we want to target in the next 20 years?

### **RESTORATION**

The restoration group chose to focus its work on nearshore restoration projects.

### **What decisions are sensitive to climate and why?**

***Instream Flows*** were seen as sensitive because they are forever decisions and could result in the loss of salmon habitat forever. Climate change may result in potential changes in channel morphology, sediment loads and water availability.

#### ***Goals and objectives for restoration (performance measures)***

This was seen as sensitive on a project by project basis – some locations will be more likely to experience alternation from climatic changes, for example sea level rise or increased erosion, and objectives may need to be reassessed in these areas.

#### ***Design (sizing and screen lifespan) and prioritizing stream crossings***

Sizing of fish passage structures was considered sensitive because changing flow regimes and changes in sediment and debris flow could reduce design life of the structures, and lead to road washouts, fish strandings, barriers to migration and loss of habitat connectivity. Possible changes in fish species and distribution was also seen as an issue related to prioritizing repairs and projects because not considering these shifts may lead to misallocating resources to less important projects.

#### ***Design and prioritization of nearshore and estuary restoration projects***

Developing the design of specific projects is sensitive in that the design should be robust to a reasonable range of projected impacts – particularly sea level rise, but also changes in hydrology and sediment movement. Prioritization of projects should consider the risks and benefits of restoration in light of future conditions.

***Adaptive management – Choice of metrics, how implemented, baseline.***

Climate Change increases liability, and the success of objectives may be at risk.

**Adaptation Options**

1. Evaluate WDFW lands through the lens of climate change and determine which are most sensitive to climate.
2. Review Chinook habitat recovery goals and projects in light of Beechie model – determine which actions will restore habitat and also mitigate for future climate impacts on the system.
3. Demonstrate WDFW's (public land) commitment to Chinook recovery.
4. Prioritize actions that are climate smart and tell story that is compelling to the agriculture community.
5. Simulate different goals and run cost/benefit through climate change to match best options with best parcels. Create a robust set of options, those likely to succeed in light of a range of climate scenarios.
6. Internal conflict regarding sometimes competing goals at WDFW (fix it!).
7. Build in climate change consideration into design of restoration projects.
8. Help agricultural community with climate change adaptation planning.

**Considerations**

- Stakeholder interest.
- Liability and mutual benefit tailored to public (?)
- Tie climate change into our rationale for restoration.
- Land management operational costs will increase relative to climate change.
- \$\$ leveraging
- Expertise
- State sanctioned models reduce liability to science.

**Science Needs**

- Better understanding of the dynamic nature of nearshore systems and how to bring that into design.
- Refugia locations – where are they? Should we protect?
- Hydrologic modeling to account for climate change.
- Sediment budgets and reach assessment slope stability.
- Cost/benefit should validate regional benefits.
- Social issues.
- Climate change education in terms accessible to agricultural community.
- Compare restoration results to baseline data. Are baseline data available?

**Suggested Next Steps:**

*Near-term (TBD)*

*Longer-term (TBD)*

## **HARVEST MANAGEMENT**

### **What decisions are climate sensitive and why?**

***Yield models*** were seen as sensitive because they are based on historical data and on previous and static conditions. They tend to over-predict recruits per spawner, which can lead to overharvest, and may lead to false assumptions regarding percent hatchery fish among harvestable adults. The risk of not addressing these climate sensitivities was seen as very high, particularly for certain river systems and species.

***Monitoring*** was also seen as having high sensitivity, because of increased biological and ecological variability and increased uncertainty, which was seen as possibly leading to reduced harvest or increased effort. May also lead to a need to increase partnerships in terms of data sharing.

***Determining directed harvest*** (for salmon, other fish species and shellfish) was seen as having a very high climate sensitivity, because of the possibility of overharvest of vulnerable species and missed harvest opportunity with non-vulnerable species.

***Balancing recovery goals with harvest goals*** was seen as highly sensitive because variability from climate change may lead to overestimating productivity and setting unrealistic goals. As habitat capacity changes, it will change the balance of relationships between species.

### **Adaptation Options**

1. Capture climate change dynamics in models, project new distributions and stock structure.
2. Test models with new base periods reflecting climate change and use shorter, more recent data sets.
3. Develop Yield models that balance recovery goals with harvest goals. Build more long term uncertainty into population models that inform harvest decisions (precautionary yield models; see science needs)
4. For determining directed harvest, put most vulnerable populations on high priority list for monitoring.
5. Begin planning for climate change now, with other managers, including adapting to increased uncertainty.
6. Develop additional selective harvest tools and lower bycatch tools.

### **Considerations**

- Tribal agreement
- PFMC/PST agreement
- Budgets
- Agreement among fishery managers, state, tribal, federal, PFMC.



## Science Needs

- Provide guidance on climate change base periods, data sets.
- Identify gaps and suggest research and monitoring to address.
- Inventory existing models and which parameters/data sets may be most vulnerable.
- Examine model performance.
- Identify most vulnerable populations and why.
- Improved monitoring for most vulnerable species, for both productivity and harvest impacts.
- Projections of climate change impacts- species that will do well and species that won't?
- Review HGMPs for climate change.
- Evaluate methods for incorporating uncertainty.
- More understanding of productivity dynamics of "other" species, the ones we don't focus on.

## Suggested Next Steps

*Nearer Term (TBD)*

*Longer Term (TBD)*

## HYDRAULIC PERMIT APPROVALS

### What decisions are climate sensitive and why?

**Guidelines (project design)** was seen as climate sensitive because changes in flows might require different design specifications, for example in culverts.

**Implementing the law** is potentially vulnerable to climate change because future conditions will alter how to protect fish life. Greater flows of water and sediment have the potential to overwhelm the structure and pose risks to public safety. Fish Passage failure creates liability. This activity was seen as highly sensitive because it means we may fail to protect fish life. It depends on the life of the project but if we fail to consider climate change we are not doing our job (liability concerns). May violate federal law.

**Construction timing** was seen as sensitive to climate because techniques may change, climate change introduces uncertainty in terms of ratios, and limiting factors might change.

**Assess impacts** -- above ordinary high and below ordinary high. This decision is potentially sensitive because habitats may shift over time, and potential for net loss of habitat. Seen as high likelihood of impacting our success.

## Adaptation Options

1. For Guidelines, we need to start with stakeholders. Options include updating guidance, or changing RCW/WAC.
2. When providing Technical Assistance, we could start considering future condition (this is something that could start now).
3. In order to implement the Law, we could change law (RCW & WAC) to require consideration of future conditions.

4. In order to implement the law we could change the 5 year limit to ~50 year limit (or some other period)
5. Provide incentives/programs to encourage sponsors to consider climate change.
6. For Assess Impacts, we could consider future “habitat” conditions and expand mitigation options.

### **Considerations**

- Public and political buy-in is essential
- The location and life of the project are a big determinant of the sensitivity to climate change. Is lifespan shorter than when we expect climate change effects to become evident? Will the “standard” life of project change due to climate change? Will this change applicants behavior? Cost – risk analysis
- Change from “current condition” to “future condition”.
- Staff need to be trained in climate change risk analysis and become “Salespeople” for conservation
- Messages need to be consistently delivered.
- We can expect resistance to increased costs (say from resizing culverts to accommodate future flows)
- Reliance on BAS (Best Available Science) is a politically charged concept

### **Science Needs**

- Quantitative flow projections
- Cost/benefit analysis
- Risk analysis
- Historical analysis of using “current condition”
- Projections of floodplain/nearshore inundation.
- Projections of future conditions on a local scale.
- Risk to conservation goals.

### **Suggested Next Steps**

*Near Term (TBD)*

*Longer Term (TBD)*

## **5.0 Workshop Evaluation and Ideas for Next Steps**

### **FULL GROUP EVALUATION AND BRAINSTORM ABOUT NEXT STEPS**

Following the small-group work, participants engaged in a discussion to evaluate the workshop process and to suggest ideas for moving forward. Several strong themes and some specific next steps emerged from this discussion. For example, most of the groups noted the need for more external communication and outreach about climate change. Many felt that more public buy-in and support for decisions based on future climate change projections were essential towards making many of the adaptation options feasible. The need for training staff was also mentioned by several, with suggestions for case studies and demonstration projects. This discussion is summarized below.

## **Workshop Process Evaluation**

In general, participants found the structured, step-by-step approach to identifying climate sensitive decisions to be helpful, although there were suggestions for how to streamline and improve the process. On the plus side, the process helped some to see in a very applied way how climate change might affect the work we do day to day. In another sense, the workshop helped to move climate change from an abstract concept into one which they could relate with the work of the agency. For improvements, some suggested limiting the presentations on climate science on the first day, and streamlining the small group work. Others felt that the work would be enriched with all WDFW Programs fully represented.

## **Did the focus on one watershed help the group in its work?**

Without a doubt, limiting our area of inquiry to the Skagit made the workshop more manageable in terms of limiting the scope of activities to consider and focusing on actual locations in the watershed - taking it out of the abstract. It also allowed for a deeper look into how climate might affect the watershed. For example, presentations about the climate science were focused on Skagit specific issues such as glacier melt and sediment issues in the river, and how sea level rise might be attenuated by accretion in some deltas but not others. When discussing restoration or hatcheries, it allowed participants to talk about a specific hatchery or restoration site so we could discuss specific characteristics of the project and have an applied versus abstract conversation.

## **Statewide Applicability**

To a large degree the findings themselves, meaning the list of climate sensitive decisions and adaptation options for each activity, were not unique to the basin or the Skagit geography and with a few exceptions could be applied statewide.

## **Suggestions on how to advance Climate Adaptation**

### **IMMEDIATE NEXT STEPS**

- Start writing proposals for filling science needs
- Host a similar workshop on the eastside (different climate issues)

### **TOOLS and/or GUIDANCE to help advance adaptation**

- Develop concrete examples, i.e., case studies
- Develop guidance for explicit decisions to address under a range of climate scenarios
- Demonstration projects – start where we are already doing the work; document and provide examples. Could we do a pilot project? Cross-discipline focus presented to EMT to demonstrate short-term success

### **EXTERNAL COMMUNICATION and EDUCATION**

- We should begin conversations now with those we work with - talk is free! For instance, begin conversations with tribes, with engineers, with citizens.
- WDFW has an important responsibility and role to communicate about climate change
- Governor's leadership presents an opportunity; WDFW should challenge other managers

## INTERNAL COMMUNICATION AND EDUCATION

- How do we show/demonstrate importance within our own organization?
- We need additional education of staff

## EXISTING POLICY and PLANS

- How can we work expected climate change impacts into existing policy? Infuse into existing decision structures and plans.
- Recovery Plans (Chinook and steelhead) – how do we include climate change impacts?

## 6.0 Concluding Observations

This workshop represented an important step in building WDFW's capacity for responding to climate change. By choosing *decisions* the agency makes as the focal point for our conversation, the workshop produced specific and precise discussions on the nature of the risks climate change poses to agency activities, as opposed to abstract discussions of potential, generalized impacts. Most participants came away with a richer understanding of how climate change may affect both the work we do collectively as an agency and our individual every-day responsibilities.

While there is much more to be done to flesh out and evaluate a fuller suite of options for adapting our activities, the workshop provided an applied framework and structure for this conversation, and a foundation for a more focused inquiry in the future. At the start of the workshop a few participants stated it was easy to feel overwhelmed regarding how to deal with climate change. By clarifying our understanding of how, when and where to incorporate variables from climate change expectations, staff can develop modifications to existing activities and decision-making as needed.

We conclude that applying this workshop model throughout the state would be an effective way for staff to learn and explore climate change adaptation options, and for the agency to develop a more effective response to climate change.

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## 8.0 APPENDICES

1. Workshop Agenda
2. List of Attendees
3. Completed Wall Charts

**Achieving Fish Management and Salmon Recovery Goals in a Changing Climate  
– a Pilot Workshop for WDFW in the Skagit Basin**

Padilla Bay Reserve, Mt Vernon

February 27<sup>th</sup> – 28<sup>th</sup>, 2013

**Goals:**

1. Advance understanding of how climate change will affect our ability to achieve our goals for fish management and salmon recovery – in the Skagit basin and statewide.
2. Explore options to integrate climate change into decision making processes
3. Identify adaptation priorities and next steps

**AGENDA**

<b>Wednesday, FEBRUARY 27<sup>th</sup></b>	
10:00	<p><b>Welcome and overview agenda</b></p> <p><b>Keynote Presentation: “Making Climate Adaptation Real</b> – examples from the field” Dr. Jennie Hoffman, founding director, EcoAdapt, and co-author of the 2011 book, “Climate Savvy, Adapting Conservation and Resource Management to a Changing World”.</p>
10:45	<p><b>Overview of WDFW’s work in the Skagit Basin</b> Developing a common understanding of where WDFW works on the landscape and our key activities and responsibilities in the basin, Bob Everitt, Region 4 Director and participants.</p>
<b>CLIMATE IMPACTS ON FISH AND THEIR HABITAT</b>	
11:00	<p><b>Introduction to Climate Impacts in the Skagit</b> – Ingrid Tohver, Climate Impacts Group How projected climatic change will affect snow pack, precipitation, hydrology, storms and sea level rise in the Skagit.</p> <p><b>How Climate Change will affect salmonids in the Skagit</b>, Ed Connor, Seattle City Light and Jon Reidel, National Park Service. An overview of how climate change impacts will affect habitat quality in the Skagit, and salmonids throughout their life history.</p> <p><b>Sea Level Rise and Sedimentation in the Skagit – implications for future restoration</b> Eric Grossman, research scientist, USGS</p>
12:30	<b>LUNCH</b>
1:15	<p><b>Debrief on presentations</b> – What did you hear? What questions did you have? What did you want to hear more about?</p>

1:30	<b>Climate-sensitive decisions and Climate-smart conservation</b>
2:00	<b>Working Session</b> Small groups identify how climate will impact our ability to achieve our goals in key topic areas, and specifically how it may impact decisions we make.
3:15	<b>Case Study Working Session</b>
	Review a case study to explore how and when to ask the climate question in project design and implementation, and how to address issues that may arise.
4:30	<b>Wrap up Day One</b>
<b>THURSDAY, FEBRUARY 28<sup>th</sup></b>	
9:00	<b>Welcome and Review of Day one</b>
<b>ADAPTATION RESPONSES FOR AQUATIC SYSTEMS</b>	
9:15	<b>Integrating climate adaptation into salmon restoration projects</b> , Tim Beechie, Northwest Fisheries Science Center, NOAA  <b>Opportunities to increase resilience for salmonids</b> , Correigh Greene, Northwest Fisheries Science Center, NOAA
10: 15	<b>Working Session – Developing an Adaptation Roadmap</b>
	Small groups focus on WDFW decisions and activities with a high climate risk, and create a draft adaptation roadmap. Questions groups will consider include: <ul style="list-style-type: none"> <li>• How should we think differently about this activity/decision</li> <li>• What science is needed and why?</li> <li>• What policy implications exist for this activity?</li> <li>• What guidance or technical assistance may be needed?</li> <li>• Would this climate risk apply statewide? Agency-wide?</li> <li>• What should be flagged for follow up?</li> </ul>
12:00	<b>LUNCH (provided on site)</b>
12:30	<b>Review key findings from small groups</b>
1:00	<b>Skagit Basin to Statewide</b> Full group discusses what impacts and adaptation options apply statewide, in other basins or as an agency wide need/activity. What next steps should be pursued in the short term?
1:45	<b>Wrap Up</b>
2:00	<b>Adjourn</b>



**ATTENDEES - SKAGIT CLIMATE WORKSHOP -- FEBRUARY 27-28, 2013**

**Planning Team (WDFW):**

Lynn Helbrecht, Climate Change Coordinator, Habitat Program, Olympia  
Bob Warinner, Area Habitat Biologist, Region 4  
Anne Marshall, Research Scientist, Fish Program, Olympia  
Amy Windrope, Habitat Program, Olympia

**WDFW**

Erik Neatherlin, Science Manager, Fish Program  
Steve Stout, Marblemount Hatchery, Fish  
Ken Warheit, Research Scientist, Fish  
Bill Tweit, Director's Office, Columbia River Policy  
Eric Anderson, District Fish Biologist R3  
Travis Maitland, Fish Biologist R2, Wenatchee  
Joe Anderson, Research Scientist, Puget Sound Wild Salmon Production  
Neala Kendall, Research Scientist, Fish  
Annette Hoffman, R4 Program Manager, Fish  
John Weinheimer, District Fish Biologist R5  
Lisa Veneroso, Assistant Director, Habitat  
Jeff Davis, Deputy Assistant Director, Habitat  
Tim Quinn, Chief Scientist, Habitat  
David Price, Restoration Division Manager, Habitat  
David Brock, R4 Program Manager, Habitat  
Stephan Kalinowski, R6 Program Manager, Habitat  
Brian Williams, R4 Environmental Planner, Habitat  
Julie Henning, Environmental Planner, Fish Passage, Habitat  
Kirk Lakey, R4 Watershed Steward, Habitat  
Wendy Cole, Area Habitat Biologist, R4  
Pat Chapman, Environmental Planner, HPA Program Lead, Habitat  
Bob Everitt, R4 Regional Director  
Belinda Rotton, Lands, R4, Wildlife  
Loren Brokaw, Environmental Specialist R4, Wildlife

**CONSERVATION PARTNERS AND CLIMATE EXPERTS**

Mary Mahaffy, Science Coordinator, USFWS, NPLCC  
Dave Peterson, North Cascadia Adaptation Partnership (USFS)  
Lara Whitely Binder, Climate Impacts Group, UW  
Guillaume Mauger, Climate Impacts Group, UW  
Carol Macilroy, Skagit Climate Science Consortium  
Ron Tressler, Seattle City Light

Margaret Duncan, Seattle City Light  
Dan Siemann, National Wildlife Federation  
Jennie Hoffman, EcoAdapt  
Ingrid Tohver, Climate Impacts Group  
Tim Beechie, NW Fisheries Science Center, NOAA  
Eric Grossman, USGS  
Correigh Greene, NW Fisheries Science Center, NOAA  
Jon Reidel, National Park Service  
Ed Connor, Seattle City Light

**ACQUISITION (MARY MAHAFFY facilitator)**

Climate Sensitive Decisions	Why is this decision vulnerable?	How like is it that climate will affect success?	What other information is needed?
1. Goals and criteria for selection (“do we buy this property?”)	<ul style="list-style-type: none"> <li>○ Species range and habitat shifts</li> <li>○ Coastal inundation</li> <li>○ Sensitivities of different habitats.</li> <li>○ Fire regimes.</li> <li>○ Changing land use around the property</li> </ul>	<ul style="list-style-type: none"> <li>○ Will your species range be affected by climate change?</li> <li>○ Will the site still provide needs and what you want from it (intended benefits).</li> <li>○ What is the consequence of not meeting goals?</li> <li>○ Will climate change affect maint. costs?</li> </ul>	<ul style="list-style-type: none"> <li>○ Can management address the vulnerabilities of habitat, species, ecological processes, use of property?)</li> <li>○ A better understanding of what information is needed versus desired.</li> </ul>
2. Do we develop a connectivity strategy and will this acquisition fit in?	<ul style="list-style-type: none"> <li>- Will connectivity change in time?</li> <li>- Will resource distribution change?</li> </ul>	<ul style="list-style-type: none"> <li>- Riparian zone health/flow levels.</li> <li>- SLR impacts , water quality changes (temperature/sediment) could all affect success of connectivity variable. Some will be more resilient to change than others.</li> </ul>	<ul style="list-style-type: none"> <li>- What new species may move in and what management is needed – what do they need?</li> <li>- Where are the critical zones likely to be for targeted species.</li> </ul>
3. How do we establish ecosystem objectives for lands we already manage?	<ul style="list-style-type: none"> <li>○ How does ecosystem integrity change with climate change?</li> </ul>		Is the structure of your monitoring plan adequate?
4. Is there an opportunity for restoration of the site or does this add to protection plans.			

5. Will this land provide intended public use/access (hunting, fishing, watchable wildlife).	<ul style="list-style-type: none"> <li>Will the resources/uses still be there years from now?</li> </ul>	Maintenance and operational costs for boat launches will increase. Engineered solutions for fish ladders/culverts/walkways O & M will increase.	What are longterm O & M costs given climate change and expected life of project (i.e., is project worth the cost).
6. How do you identify what your priorities are and allocate resources?	<ul style="list-style-type: none"> <li>How will climate change affect the identified priorities.</li> </ul>		

Climate Sensitive Decisions	Adaptation Option	Policy Implications (Issues, obstacles and opportunities)	Science or Information Needs (why?)	Stakeholders who need to be engaged
Selecting/prioritizing acquisitions based on future species richness and biodiversity.	<ul style="list-style-type: none"> <li>Develop strategy: Purchase more complex habitats so if one fails, others will flourish. Don't buy for single species.</li> <li>Look at likely future climate at selected site to evaluate if site will support targeted species/habitat/ecosystem service.</li> <li>Acquire land for species at risk now and plan for needs to benefit them later.</li> <li>Ex., select areas above water now that will be good eelgrass beds in the future.</li> </ul>	<ul style="list-style-type: none"> <li>Cost to maintain land for intended use (eg, invasives impacts)</li> <li>Variation in cost of different lands and opportunities for purchasing them.</li> <li>Climate change themes of alarmists and overreaction.</li> </ul>	<p>Will future conditions increase or decrease biodiversity.</p> <p>Look at current conditions vs. what will look like in future and see if purchase is worthwhile.</p>	Private landowners Local planners Counties, and others potentially impacted from regs or benefit from biodiversity.
Species Connectivity	-	-	Understanding potential species movements/future conditions.	

What/how do we select for public use/access	<ul style="list-style-type: none"> <li>- Look at future climate to see if it will be able to support public access/use as intended</li> </ul>	<ul style="list-style-type: none"> <li>- Need funding sources to buy in especially when not best of last remaining now but will be later. Shift in priorities funding opportunities.</li> <li>- Funders expect land to provide single function forever/climate will change this.</li> <li>- What you don't buy because of potential climate change impacts negative reactions from interest groups that bring property forward.</li> <li>-</li> </ul>	Better understand future conditions.	
Buying land today to increase instream flow for fish.	<ul style="list-style-type: none"> <li>- Strengthen relationships and look for or take advantage of opportunities.</li> <li>- Work with federal agencies, utilities, tribes, timber companies to identify opportunities to set connected lands.</li> </ul>	-	- Who controls the water today?	

Buy lands to support natural ecological processes.	<ul style="list-style-type: none"> <li>○ Draw linkages to ecological and social functions and uses through the lens of climate change to plan for future years.</li> <li>○ Integrate climate change into Lands 20/20 process</li> </ul>	<ul style="list-style-type: none"> <li>○ Problem with funding application often don't have climate change as a factor (but can add). Add intended use longterm.</li> </ul>	<ul style="list-style-type: none"> <li>○ Monitor to see if investments will provide intended benefits. Performance management; see how habitats fit into big mosaic.</li> </ul>	<ul style="list-style-type: none"> <li>○</li> </ul>
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## HATCHERY MANAGEMENT (ERIK NEATHERLIN facilitator)

Climate Sensitive Decisions Could climate affect our ability to achieve our goals?	Why is this decision vulnerable?	How like is it that climate will affect success?	What other information is needed?
<p>1. Flow management</p> <ul style="list-style-type: none"> <li>○ Spring – lots more water</li> <li>○ Fall – already seeing some limitations to flow.</li> </ul>	<ul style="list-style-type: none"> <li>● If water is not available, then increasing cost, eg.g., have to run wells.</li> <li>● If cooler – slow growth?</li> </ul>	<p>LIKELY to affect surface water, especially in Fall.</p> <p>COULD also affect ground water and well water availability</p>	<ul style="list-style-type: none"> <li>○ Models to help us understand ground water flow (specific to wells)</li> <li>○ Need to better understand flood window (seasonality)(for example, do not put fish in pond until Dec 15).</li> <li>○ Flood can affect the whole facility. Location of facility can affect maintenance.</li> </ul>
<p>2. Release Dates</p> <ul style="list-style-type: none"> <li>● Want to maximize survival</li> <li>● Maximize physical condition</li> </ul> <p>GOAL – Match natural migration of fish</p> <ul style="list-style-type: none"> <li>● Want to minimize potential impact to wild fish (related to release date)</li> <li>● Matching fish size and optimal environmental conditions for survival (historical food, resources, water temp, flow).</li> </ul>	<ul style="list-style-type: none"> <li>● Decisions are a year out, so requires A LOT of planning. Advance information is required.</li> </ul> <p>Potential consequences:</p> <ul style="list-style-type: none"> <li>- Affects fisheries.</li> <li>- Survival requirements</li> <li>- Impacts to wild fish.</li> </ul>	<p>** NEED better and more science.</p> <p>VERY LIKELY: If timing in the est.. of food resources is changing then may need to change release time to affect size of hatchery fish.</p>	<ul style="list-style-type: none"> <li>- Turbidity not an issue at marbelemount.</li> <li>- In general, more interaction with scientists would/could improve.</li> <li>- Do we have monitoring for how release dates are working.</li> </ul>

<b>Climate Sensitive Decisions Could climate affect our ability to achieve our goals?</b>	<b>Why is this decision vulnerable?</b>	<b>How like is it that climate will affect success?</b>	<b>What other information is needed?</b>
3. Brood stock collection. Returning smolts to adult return Survival SAR – tie into harvest management	<ul style="list-style-type: none"> <li>• If ocean survival is poor, decreasing broodstock abundance.</li> <li>• May affect how you collect broodstock.</li> <li>• May affect type of program you can have.</li> </ul>	VERY LIKELY for species of low abundance. IF ocean DECREASES survival, then likely to have an effect. Also depends on integrated vs segregated. If flow changes then could affect ability to get fish for broodstock.	Idea of what decisions are made year to year. Or, what are affected by long term climate change.
4. Disease Issues (in hatcheries and post release)	<ul style="list-style-type: none"> <li>•</li> </ul>	VERY LIKELY	If we start to see more frequency of diseases then may be due to climate change.  Do we shift to different water source?

<b>Climate Sensitive Decisions</b>	<b>Adaptation Option</b>	<b>Policy Implications (Issues, obstacles and opportunities)</b>	<b>Science or Information Needs (why?)</b>	<b>Stakeholders who need to be engaged</b>
How we manipulate flows	<ul style="list-style-type: none"> <li>• Changing surface flow into the hatchery.</li> <li>• Changing flows from wells using pumps.</li> <li>• Recirculation strategies.</li> <li>• Find different water sources.</li> <li>• Increase water sources</li> <li>• Punch in new well</li> </ul>	<ul style="list-style-type: none"> <li>• If the costs of altering flow goes up or availability changes, then need to tee up a discussion.</li> <li>• Do we have to reconstruct wells or water availability?</li> <li>• Increase water rights ???!</li> <li>• Hatchery Scientific Review Group</li> <li>• Fishery Mgmt/co-mgmt</li> <li>• Fishery Implications</li> </ul>	Information/monitoring data on flows and availability. Water temperature. General water availability and trends. Is disease related to water sources?	Fishery managers and co-managers.  Ecology  Private landowners.



Release dates (very related to flow)	<ul style="list-style-type: none"> <li>○ Release fish smaller, if we don't have the capacity or flow to release later.</li> <li>○ Release timing for fish.</li> <li>○ Manual that documents changes.</li> <li>○ Matching natural migration</li> <li>○ Multiple timing releases for single broodstock.</li> </ul>	<ul style="list-style-type: none"> <li>○ Harvest management: if you release smaller – higher mortality and less fish.</li> <li>○ Can affect broodstock collection</li> </ul>	<ul style="list-style-type: none"> <li>○ Understanding freshwater ecological consequences (eg, altering size of release)</li> </ul>	<ul style="list-style-type: none"> <li>○ Fishery mngers/co-mangers</li> <li>○ Advocates of natural fish pops</li> <li>○ International treaties.</li> <li>○ Fishing constituents.</li> </ul>
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## FISH PASSAGE

Climate Sensitive Decisions Could climate affect our ability to achieve our goals?	Why is this decision vulnerable?	How like is it that climate will affect success?	What other information is needed?
1. Engineering Design <ul style="list-style-type: none"> <li>Sizing</li> <li>Screen lifespan</li> </ul>	Flow regimes Sediment and debris flows will change Ice Temperature Structures may have reduced design life.	Road washouts Fish strandings Barriers to migration Thermal death Loss of habitat connectivity Increased competition for water (low flow )	<ul style="list-style-type: none"> <li>Refugia locations</li> <li>Hydrologic modeling to account for climate change.</li> <li>Sediment budgets and reach assessment slop stability .</li> </ul>
2. Assessment of Habitat Prioritizing repairs and projects	<ul style="list-style-type: none"> <li>Changes in fish species distribution</li> <li>Alter rankings of priorities (abandonment?)</li> <li>Criteria may change.</li> </ul>	Might misallocate resources to less important projects.	<ul style="list-style-type: none"> <li>Species targets</li> <li>Same info as above</li> </ul>

## RESTORATION (Tim Quinn facilitator)

Climate Sensitive Decisions Could climate affect our ability to achieve our goals?	Why is this decision vulnerable?	How like is it that climate will affect success? What is the risk of not	What other information is needed?
5. Instream Flows	<ul style="list-style-type: none"> <li>Forever decisions</li> <li>Loss of salmon habitat forever</li> <li>Year to year variability</li> </ul>	Very likely, perhaps less in rain dominated systems. Glacier and snow fed.	Overlay between ... ownerships with water rights.

	<ul style="list-style-type: none"> <li>Potential changes in channel, sediment</li> </ul>		
6. Goals and objectives for restoration (performance measures)	<ul style="list-style-type: none"> <li>Project by project</li> </ul>		Need to build in diversity (dynamic nature of physical properties)
7. Design and prioritizing stream crossings	<ul style="list-style-type: none"> <li>Changes to hydrology</li> </ul>		
8. Nearshore and estuary restoration – design and prioritization.	<ul style="list-style-type: none"> <li></li> </ul>		
9. Adaptive management – Choice of metrics, how implemented, base line.	<ul style="list-style-type: none"> <li>Climate Change increases liability.</li> <li>Success of objectives may be at risk.</li> </ul>		

Climate Sensitive Decisions	Adaptation Option	Policy Implications (Issues, obstacles and opportunities)	Science or Information Needs (why?)	Stakeholders who need to be engaged
Nearshore and estuary restoration	<ul style="list-style-type: none"> <li>Evaluate WDFW lands through the lens of climate change model;</li> <li>ID lands relative to current goals given climate change (risk).</li> <li>Review Chinook goals in light of Beechie model (other salmon wildlife).</li> <li>Demonstrate WDFW's (public land) commitment to Chinook recovery.</li> <li>Prioritize actions that are efficient and tell story that is compelling to the agriculture community.</li> </ul>	<p>Stakeholder interest.</p> <p>Liability and mutual benefit tailored to public (?)</p> <p>Tie climate change into our rationale for restoration.</p> <p>Land management operational costs will increase relative to climate change.</p>	<p>Cost/benefit should validate regional benefits.</p> <p>Social issues.</p> <p>Climate change education in terms accessible to Ag.</p> <p>Compare restoration results to baseline data.</p>	<p>Ag, county, Tribes, Corps, User groups, hunters, fishers.</p> <p>Legislature and community support.</p>

	<ul style="list-style-type: none"> <li>• Simulate different goals and run cost/benefit through climate change to match best options with best parcels.</li> <li>• Internal conflict regarding goals at WDFW (fix it!).</li> <li>• Build in climate change consideration into design.</li> <li>• Help Ag with climate change adaptation planning.</li> </ul>	<p>\$\$ leveraging</p> <p>Expertise</p> <p>State sanctioned models reduce liability to science.</p>	<p>Are baseline data available?</p> <p>How does the ag community make decisions?</p> <p>Target appropriate state agencies.</p>	
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- **SHORT TERM – WDFW ownerships.**
- **LONG TERM – other ownerships.**

### HARVEST MANAGEMENT (David Price and Bill Tweit, facilitators)

Climate Sensitive Decisions Could climate affect our ability to achieve our goals?	Why is this decision vulnerable?	How like is it that climate will affect success? What is the risk of not	What other information is needed?
1. Models ( <i>importance with #5?</i> )	<ul style="list-style-type: none"> <li>• Based on past data.</li> <li>• Based on previous/static conditions.</li> <li>• Tends to over predict overharvest.</li> <li>• False assumptions (pH)</li> </ul>	<p>VERY HIGH !!1</p> <p>Exist.... For some species and river systems.</p>	
2. Monitoring	<ul style="list-style-type: none"> <li>• Increased variability = increased uncertainty = reduced harvest or increased monetary effort.</li> <li>• May need to increase partnerships (share data)</li> <li>•</li> </ul>	<p>HIGH</p>	

3. Determining directed harvest (salmon, all fish, shellfish) (species, stock, hatchery vs wild fish)	<ul style="list-style-type: none"> <li>Overharvest vulnerable species.</li> <li>Missed harvest opportunity with non-vulnerable species.</li> </ul>	VERY HIGH	
4. Recovery goals balanced with harvest goals	<ul style="list-style-type: none"> <li>Overestimating productivity sets unrealistic goals.</li> <li>Habitat capacity changes, changing balance relationships</li> </ul>	VERY HIGH	
5. Develop Yield Models	<ul style="list-style-type: none"> <li>Overestimate production = overharvest = increase extinction risk</li> </ul>	VERY HIGH	

Climate Sensitive Decisions	Adaptation Option	Policy Implications (Issues, obstacles and opportunities)	Science or Information Needs (why?)	Stakeholders who need to be engaged
1. MODELS	<ul style="list-style-type: none"> <li>Capture climate change dynamics in models, new distributions, stock structure.</li> <li>Test models with new base periods reflecting climate change.</li> <li>Use shorter, more recent data sets.</li> </ul>	Tribal agreement PFMC/PST agreement Budgets	<ul style="list-style-type: none"> <li>Provide guidance on climate change base periods, data sets.</li> <li>Identify gaps and suggest research and monitoring to address.</li> <li>Inventory existing models and which parameters/data sets may be most vulnerable.</li> <li>Examine model performance.</li> </ul>	All recreational and commercial harvesters.
3. Determining directed harvest	<ul style="list-style-type: none"> <li>Put most vulnerable populations on high priority list for monitoring.</li> <li>Begin Planning for climate change now, with other managers, including adapting</li> </ul>	Agreement among fishery managers, state, tribal, federal, PEMC.  Legislation?	<ul style="list-style-type: none"> <li>Identify highest vulnerability populations.</li> <li>Improved monitoring for most vulnerable species. Both productivity and harvest impacts.</li> </ul>	Harvesters, NGOs, Salmon Recovery Boards, Other Hs.

	to increased uncertainty. <ul style="list-style-type: none"> <li>• Develop additional selective harvest tools, lower bycatch tools.</li> </ul>		<ul style="list-style-type: none"> <li>• Projections of climate change impacts, species that will do well and species that won't?</li> <li>• Review HGMPs for climate change.</li> <li>• Evaluate methods for incorporating uncertainty.</li> </ul>	
4. and 5.  Develop Yield models, balance recovery goals with harvest goals	Building more long term uncertainty into population models (that inform harvest decisions), [precautionary yield models]. **		** More understanding of productivity dynamics of "other" species, the ones we don't focus on.	

### HPAs (BOB WARINNER facilitator)

Climate Sensitive Decisions	Why is this decision vulnerable?	How like is it that climate will affect success?	What other information is needed?
1. Guidelines (project design)	Flows might require different methods (culverts)	<ul style="list-style-type: none"> <li>○ Yes – greater flows of water and sediment would overwhelm structure.</li> <li>○ Structure failure = risks to public safety.</li> <li>○ Fish passage failure creates liability.</li> </ul>	<ul style="list-style-type: none"> <li>○ More science.</li> <li>○ More public awareness (social science).</li> </ul>
2. Implement the law	Future conditions will alter how to protect fish life	<b>HIGH</b> <ul style="list-style-type: none"> <li>- May fail to protect fish life.</li> <li>- Depends on the life of the project.</li> <li>- If we fail to consider climate change we are not doing our job (liability concerns).</li> <li>- May violate federal law.</li> </ul>	<ul style="list-style-type: none"> <li>- Public buy in</li> <li>- Life of the project</li> <li>- Location of the project</li> </ul> <b>LIFE OF PROJECT</b> <ul style="list-style-type: none"> <li>- Is life shorter than when we expect climate change effects?</li> </ul>

			<ul style="list-style-type: none"> <li>- Will the “standard” life of project change due to climate change?</li> <li>- Will this change applicants behavior? Cost – risk analysis</li> </ul>
3. Mitigation	Construction timing Techniques Ratios (uncertainty) Change of limiting factors	Liability	
4. Assess impacts - Above ordinary high - Below ordinary high	<ul style="list-style-type: none"> <li>• Habitat shifts</li> </ul>	HIGH LIKELIHOOD Greater habitat impact (net loss) Impacts not identified.	Predictions of local change.

Climate Sensitive Decisions	Adaptation Option	Policy Implications (Issues, obstacles and opportunities)	Science or Information Needs (why?)	Stakeholders who need to be engaged
Guidelines	Need to start with stakeholders  <ul style="list-style-type: none"> <li>○ Update guidance</li> <li>○ Change RCW/WAC</li> <li>○ Consider future conditions when providing technical assistance.</li> </ul>	<ul style="list-style-type: none"> <li>○ Change from “current condition” to “future condition”.</li> <li>○ Political Lobby</li> <li>○ Staff trained in climate change risk analysis</li> <li>○ Salespeople for conservation</li> <li>○ Messages consistently delivered.</li> </ul>	<ul style="list-style-type: none"> <li>○ Quantitative flow projections</li> <li>○ Cost/benefit analysis</li> <li>○ Risk analysis</li> <li>○ Historical analysis of using “current condition”</li> <li>○ Life of project</li> </ul>	County engineers Timber Cos. WSDOT and Feds Tribes Landowners

Implement the Law	<ul style="list-style-type: none"> <li>○ Change law (RCW &amp; WAC) to require consideration of future conditions.</li> <li>○ Change 5 year limit to ~50 year limit (or something)</li> <li>○ Incentives/programs to encourage sponsors to consider climate change.</li> </ul>	<ul style="list-style-type: none"> <li>○ Resistance to increased costs</li> <li>○ Opposition from stakeholders</li> </ul>	<ul style="list-style-type: none"> <li>○ Cost/Benefit analysis.</li> <li>○ Risk Analysis</li> <li>○ Risk to conservation goals</li> </ul>	<ul style="list-style-type: none"> <li>○ Private and public building community</li> <li>○ Tribes</li> <li>○ Environmental Community</li> </ul>
Assess Impacts	<ul style="list-style-type: none"> <li>○ Consider future “habitat” conditions</li> <li>○ Open/expand mitigation options</li> </ul>	<ul style="list-style-type: none"> <li>○ Reliance on BAS is a politically charged concept</li> </ul>	<ul style="list-style-type: none"> <li>○ Projections of floodplain/nearshore inundation.</li> </ul>	<ul style="list-style-type: none"> <li>○</li> </ul>